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BIOLOGICAL RESEARCH SECTION 1986 ANNUAL REPORT

Report No 87-88-K

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ABSTRACT

The activities and accomplishments of the Biological Research Section during 1986 are reviewed. Major projects planned for 1987 are also identified.

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To Dr. D. Mills
Director of Research

BIOLOGICAL RESEARCH SECTION
1986 ANNUAL REPORT

INTRODUCTION

The Biological Research Section, located in Building KD of the Kipling Complex (800 Kipling Avenue, Toronto), is a unit within the Ontario Hydro Research Division. The Section is functionally responsible for conducting directed basic research and scientific investigations related to the biological sciences in support of Ontario Hydro's planning and operational activities.

This document provides an overview of major activities undertaken by the Section during 1986, highlights some major accomplishments and describes major areas of endeavour planned for 1987.

The Section's structure is a semi-matrix pattern with one unit and three major program areas (Appendix A). The Aquatic Surveys and Programs Unit consists of a core of biologists and technicians whose major function is to provide an environmental support service for the design and operational departments of Ontario Hydro. The majority of the Unit's effort has been directed toward pre- and post-operational aquatic studies at new generating facilities. The three programs (Fish Control, Vegetation Control and Radiobiology), through a technical coordinator, draw upon the expertise of the Section's professional and technical staff to address specific areas of research. The major distinction between the Unit and the Programs is their longevity.

In May 1986, the Supervising Biologist, Dr. G.L. Vascotto, was rotated into a new position as Senior Research Scientist reporting to the Manager - Chemical Research Department. As a result, Dr. F.S. Spencer and Dr. A.E. Christie acted as Supervising Biologist for the periods May through August and September through December, 1986, respectively. Mr. G.T. Haymes will act as Supervising Biologist during January through April, 1987.

During 1986, Dr. D.G. Brown, Ms. L. Bremmer, Mr. S. Poulton and Ms. C.A. Thomson were welcomed to the Section while Dr. V.J. Sharpe and Mr. O.B. Turczyn accepted positions elsewhere in the Corporation and Mr. G. Murphy retired.

BIOLOGICAL RESEARCH WORK PROGRAM 1986-1987

The major efforts of the Section during 1986 were distributed among four divisional program areas, Utilization and Alternate Energy Systems, Transmission, Nuclear and Environment. A brief review of the 1986 work program and planned activities during 1987 in each of these areas is presented below.

Program No 1 - Utilization and Alternate Energy Systems

Thermal Aquaculture of Malaysian Prawns

The investigations to develop a new unique aquaculture product for Ontario, the giant freshwater prawn, continued in 1986. The goals for 1986 and 1987 are to assess the feasibility of consistently growing marketable size animals in sufficient densities to make such a venture profitable.

There are two major problems that require solution, one is the fact that animals of similar age and grown under identical conditions may vary in size by several orders of magnitude, with the majority being below marketable size. The second problem is that, as yet, we do not know what growth conditions are required to optimize yield or what yields can be attained. In the latter problem progress has been made.

A food ration study was carried out to determine the feeding levels which resulted in maximum growth in isolated animals. The results of the study indicated that although smaller animals (2 and 5 gms) required close to the recommended feeding level of 5% of biomass, growth of larger animals (15 gms) could be maintained with smaller rations.

Studies during 1985 and 1986 indicated that prawns would use the complete water column when artificial substrates were provided. These results suggest that the use of cover and artificial substrate may allow a grower to increase the density of animals per unit volume of water. In one larger scale study of substrate utilization, increased growth and survival of the animals was indicated. Increases in biomass were apparent in the first four months; however, in subsequent months increased mortality was evident. The increased mortality may have resulted from contamination from external sources.

In 1985 it was reported that early results of an experiment on water flow showed different survival at different flow rates. Subsequent analyses revealed that survival in the early part of the experiment was directly related to the experimental treatment, but survival in subsequent months was most closely related to the surviving biomass in each aquaria, and conditions of rapid biomass growth were followed by high mortalities. It appears that the carrying capacity of the system had been exceeded, suggesting that either water chemistry, water volume limitation, or surface area limitations may exist. Subsequently, a second study was carried out in larger fiberglass pools to determine if the survival and biomass were linked to either water volume or available substrate. In the first month of the experiment increased survival and biomass were related to water volume, but by the end of the experiment some of the variation had disappeared, and once again water chemistry, possibly high ammonia, appeared to be causing problems. The data are still being analyzed.

During 1987, the influence of size sorting, of size related secretions and of behavioural and chemical factors on growth, development and production will be investigated. If the results of these studies are encouraging, attemps will be made to gather data under conditions emulating commercial conditions in greenhouse runways.

PROGRAM AREA 3 - TRANSMISSION SYSTEMS

Vegetation Control

The primary goal of the vegetation control program is to obtain, through research, information which may create opportunities for more effective, efficient, and environmentally responsible means of controlling undesirable vegetation on both transmission and distribution rights-of-ways. The capability to meet the goal is maintained by carrying out studies directed towards exploring novel concepts of vegetation control, attempting to improve on existing control techniques, providing environmental information, evaluating new products, and expanding the knowledge base of the cause of vegetation problems.

In 1986 studies to evaluate trunk injection of growth regulators, to identify and evaluate allelopathic species and substances, of succession on new rights-of-way and of the influence of date of cutting on subsequent sprouting were conducted.

Growth Regulators

Evaluation of the effectiveness of trunk injection of the growth regulators EL-500 and PP333 into 12-year-old silver maple trees at the Wesleyville GS herbicide study area continued. Measurements of sprout and height growth in 1986 indicated that a

high application rate of PP333 significantly reduced the growth in height of the trees. Some trees only grew in height by 2 cm. Both application rates of EL-500 and PP333 significantly inhibited the growth of terminal sprouts and the inhibition observed in 1986 was greater than that observed in 1985, the first growing season following application. Height and sprout growth will be again monitored in 1987.

Preliminary data suggest that growth regulator treatment resulted in a modification of the pattern of terminal sprout growth, with a reversal of the usual rapid early season growth followed by a decline in the rate to the end of the season. This will be further investigated in 1987.

A study of the translocation of XE1019 (a new growth regulator) following trunk injection will be initiated in 1987. Loss of growth regulator at leaf drop will be determined.

Mechanical Treatment

The field study initiated in 1983 to investigate the sprouting response of silver maple as a function of the month of cutting was concluded at Wesleyville. Trees cut during the growing season (or non-dormant period) produced sprouts with a significantly slower rate of growth and tended to suffer greater mortality than trees cut in the dormant season.

Studies at the new transmission right-of-way site at McCowan Road continued in 1986. The site was cleared of undesirable woody species in 1984. The sprouting and suckering characteristics of four species on the site were compared in the first and second years following this cutting. Total sprout density declined from 1.63 stems/m^2 in the first year to 1.17 stems/m^2 in the second year. This was primarily due to a decrease in the number of white ash sprouts and trembling aspen suckers. Of the stumps that sprouted, vigour in the sugar maple and white ash sprouts increased with increasing stump size, reached a maximum at 10 to 15 cm diameter, and then declined. Larger diameter stumps of black cherry were the more vigorous sprouters, while there appeared to be no relationship between stump diameter and suckering vigour with trembling aspen. Data on the long-term growth characteristics and survival rate of the sprouts will be collected in 1987.

Two additional studies to assess the relative importance of the growth of stump sprouts, advance regeneration and seedlings in the revegetation of a newly-cleared right-of-way by undesirable species are planned for 1987.

Allelopathy

Experiments continued to demonstrate the allelopathic potential of cover crops in resisting the invasion of rights-of-way by undesirable woody species. The total phenolics content of extracts from several cover crop species of various ages was significantly correlated with the inhibition of seed germination of two woody species. In other cover crops, however, no such correlation was found, suggesting that phenolic compounds are not the primary inhibitory agent in all species. In 1987 these studies will continue with the emphasis being placed on the isolation and partial characterization of the primary inhibitory component(s) from cover crop extracts.

Program Area 5 ... Nuclear Generation

Radionuclide Studies

The focus of the radionuclide program is to determine the biological behaviour of tritium and other radionuclides released from Ontario Hydro's nuclear facilities.

Molecular Tritium

During 1986 experimental studies to determine the processes controlling the rates of conversion of atmospheric molecular tritium (HT) to tritiated water (HTO) continued. HT is a form of tritium which will be released from the new Tritium Recovery Facility (TRF) at Darlington NGS and future fusion facilities. It has been determined that soil and associated litter is the primary site for conversion of HT to HTO and that the process is mediated by microbes.

A pilot scale field release experiment conducted through the cooperation of AECL and the Canadian Fusion Technology Program was conducted in 1986 at Chalk River. The results of this field study were similar to our results in laboratory experiments. The results also suggested that a substantial amount (approximately 1% per hour) of HTO converted in the soil is resuspended to the atmosphere.

A second comprehensive HT field release experiment with international participation is being planned for 1987. The primary focus is on quantifying the HTO resuspension process, obtaining a concensus on deposition velocities and providing a database for modelling tritium behaviour. The resuspension process is of particular importance given that HTO is about 10,000 times more radiotoxic than HT.

The influence of environmental factors on the rates of conversion of HT to HTO were conducted in the laboratory. Results confirmed that deposition velocities can be characterized in terms of rates

of diffusion and biological oxidation in surface soil. These parameters are limited primarily by water content and temperature.

Gamma Radionuclides

A laboratory study of the partitioning between sediments and water of two gamma radionuclides, ^{60}Co and ^{137}Cs, which are released by Ontario Hydro NGS to the aquatic environment was completed during 1986. ^{60}Co and ^{137}Cs adsorption distribution coefficients (Kd's) varied by more than an order of magnitude among sediment samples collected from the nearshore zone of Lake Ontario near Pickering NGS and from deeper basins with the lake. Kd's of both radionuclides were highly correlated, with ^{137}Cs Kd's approximately 10 to 20 times greater than ^{60}Co Kd's. In addition, similar variables, particularly particle size, cation exchange capacity and sediment ^{60}Co activity, were significant in regression equations predicting both ^{60}Co and ^{137}Cs Kd's. Thus, similar mechanisms may determine the adsorption characteristics of both ^{60}Co and ^{137}Cs. Sediment ^{60}Co activity was strongly correlated with the Kd's of both ^{60}Co and ^{137}Cs, and was a significant parameter in regression equations predicting Kd's of both radionuclides. Sediment ^{137}Cs activity was not significantly correlated with either Kd, however, and was a significant parameter only in regression equations predicting the ^{137}Cs Kd. These differences in the relationships of Kds' with sediment ^{60}Co and ^{137}Cs activities indicate that additional factors, such as the sources of the radionuclides to Lake Ontario, are also important to the determination of sediment radionuclide activity.

The distribution of radioisotopes of cesium and cobalt was determined in the western basin of Lake Ontario during 1986 as a follow-up of an earlier lakewide survey. A relationship between the distribution of these isotopes and potential sources was not evident.

Biofouling

Fouling of heat exchange surfaces has long been recognized as a serious maintenance problem to electrical generating stations using once-through cooling systems. The use of untreated water in heat exchangers results in the formation of a slimey film of bacteria inside the water jackets. This biofilm results in reduced rates of flow and a loss of heat exchange capacity.

Chemical and mechanical approaches to control biofouling are associated with environmental concerns or interference with station operation. Consequently novel approaches to controlling the colonization of heat exchange surfaces by microbes is required.

The participation of the Biological Research Section in this area was temporarily slowed in 1986 due to the loss of appropriate expertise in microbiology. One study conducted during 1986 investigated the potential of irradiation in reducing the number or reproductive capacity of attachment organisms in water. Following exposure to a gamma radiation source, raw Lake Ontario water contained significantly reduced numbers of the predominant attachment organisms and these attachment organisms failed to reproduce within 48 hours after exposure.

Future studies in this area will investigate the use of acoustics in restricting attachment of organisms to heat exchange surfaces and in detecting the presence of biofouling before significant deterioration of the exchange surface occurs.

Biotechnology

Hydrogenase

Several potential applications exist for ambient temperature catalysis of hydrogen conversion reactions within the areas of fusion and fission technology. Certain bacterial species are capable of producing the enzyme hydrogenase which catalyses conversion reactions between elemental and oxide forms of hydrogen, deuterium and tritium. Experimental work completed in 1986 defined the optimal concentration of iron and the most suitable carbon and nitrogen sources for maximizing growth and hydrogenase activity of the most promising bacterium, Alcaligenes entrophus. The established culture medium provides good cell growth and high hydrogenase activity. Total enzyme activity was found to be a function of specific enzyme activity, which changes during growth, and total culture biomass. This bacterial species is suitable for mass cultivation which could be required for technological application. In 1987 the conditions that maximize hydrogenase activity and the rates of hydrogen conversion reactions (eg, HT to HTO) will be determined.

Biosynthesis of Deuterated Lipids

Deuterated hydrocarbons have enhanced oxidative stability and synthetic organics, such as lubricants, produced from deuterated hydrocarbons have longer useful lifetimes than their proteated counterparts. The objective of our studies in this area is to establish capability for the biosynthesis of fully deuterated lipids from algal culture and to provide a preliminary evaluation of this production method.

The green alga, Scenedesmus obliquus, has been adapted to grow in 100% heavy water medium following a series of inoculations into progressively higher D_2O concentrations. The first mass cultures

(2 x 5 L) were established in mid-December. Work will continue into 1987 to determine the composition and yield of deuterated lipids from algal culture.

PROGRAM AREA 9 ... ENVIRONMENT

Biological Site Surveys

On behalf of Design and Development Division - Generation, biological studies are carried out in compliance with provincial regulatory agencies as part of the licensing process for new and proposed generating facilities. These studies normally consist of a definition phase in support of the Environmental Assessment document, a preoperational phase during construction, a commissioning phase and an operational phase when the station has reached full capacity. The objective of these studies is to determine through an extensive monitoring program, the effects of the construction and operation of new generating stations on the aquatic and terrestrial environment.

During 1986 studies were underway at Atikokan TGS, Bruce B NGS, Pickering B NGS, Darlington NGS and on the Mattagami River. With the exception of the Mattagami River site studies will continue at the above sites and at Big Chute on the Severn River.

Fish Control

Over much of the past decade, the Biological Research Section has developed considerable expertise in the use of various devices in attracting and repelling fish. Initially developed to reduce impingement of fish at once-through-cooling systems at Ontario Hydro generating stations on the Great Lakes, our services have been solicited for studies related to problems at thermal and hydraulic facilities throughout Canada and in the United States. In addition to studies funded by Ontario Hydro, research was conducted on behalf of the Electric Power Research Institute (EPRI), the Power Authority of New York (NYPA) and the Canadian Electrical Association (CEA).

EPRI had developed a program to evaluate the effectiveness of selected behavioural exclusion schemes at four North American sites representative of different water bodies. Pickering NGS was selected as the representative site for the Great Lakes. The two year study was completed in 1986 where the effectiveness of selected behavioural systems (strobe lights, a pneumatic popper, and air bubbles both alone and in combination) in excluding pelagic schooling alewife was determined. The pneumatic popper sound deterrent was found to be the most effective. Although effective for the target species, there were serious mechanical reliability problems with the popper which would limit their use at the intakes of generating stations.

An Ontario Hydro multi-disciplinary research program continued on the development of two accoustical sound devices (fishdrone, fishpulser) to replace the popper as a fish control device. In addition to greater reliability, these devices were also considered more flexible than the popper in generating different frequencies to address the known species specific responses to sound. In the laboratory, experiments were conducted in a unique semi-anechoic tank on the responses of several Great Lakes fish species (alewife, gizzard shad) to various frequencies and amplitudes of sound. The overall objective of this study was to develop an inference system to predict fish sensitivity to sound based on the hearing mechanism they possess.

Field trials of the fishpulser as an exclusion device were conducted at both Pickering GS and Lambton GS. At the Pickering GS Fish Diversion Structure, the fishpulser was estimated to exclude 85% of the alewife relative to that observed under control conditions. Sound pressure levels produced from the fishpulser were found to be somewhat directional, and were noted to be at least seven times higher in amplitude than those observed for a popper (EPRI studies). A full scale study at Pickering GS has been proposed for 1987.

Preliminary work was also conducted at Lambton TGS on the feasibility of using both sound deterrents for gizzard shad exclusion. Since results were encouraging further activities will be conducted in the early winter of 1987.

A study for the Canadian Electrical Association was conducted on the effectiveness of selected behavioural devices for guiding or diverting downstream migrating fish at hydro-electric facilities. Two projects were conducted outside Ontario; research on downstream migrating salmon smolts was conducted at the Seton facility in BC, and work involving a non-salmonid migrant was conducted at the Riviere-des-Prairies facility in Quebec. At Seton, results indicated that strobe lights, a pneumatic popper, and the fishpulser evoked an avoidance response in sockeye salmon smolts even at velocities approaching 1 m/s. Percent exclusion was highest for the fishpulser (75%), followed by the popper (66%) and strobe (56%) deterrents. An air bubble wand appeared to attract the smolts. These results clearly indicated the potential of low cost behavioural methods for fish control at hydro-electric facilities. At the Riviere-des-Prairies site, fish densities (American shad) were too low to evaluate the effectiveness of these devices. A proposal for investigating upstream (adult fish) migrants at hydro-electric facilities in 1987 has been submitted to CEA.

In order to reduce maintenance costs of installed behavioural devices, studies were initiated to develop an early warning system to work in association with the behavioural devices. The proposed system would monitor fish density in the area of the

intake and automatically turn on the behavioural devices when fish density reached a predetermined threshold. A fish quantification system employing three transducers was installed at the Pickering fish diversion test structure. The system was coupled to the fish pulsers so that the latter could be operated independently or switched on and off in response to changing fish densities. In preliminary trials, operation of the fish pulser was successfully mediated by the sonar. Sufficient relative fish density data was also obtained to indicate appropriate on/off thresholds for fish exclusion at that location and season. Work will continue in 1987.

In addition to those noted above, studies in 1987 are also proposed for Thunder Bay GS and on sturgeon collected from the Mattagami River. Laboratory studies are also proposed to investigate the use of sound as an attractant.

New Business Ventures have taken an interest in the Fish Control Program, and will be involved in creating business opportunities in 1987. Possible future activities include field studies at the Annapolis Tidal facility in Nova Scotia, and at a facility in New York State.

OTHER ENVIRONMENTAL STUDIES

Nanticoke Effects Study

On behalf of Stelco, Texaco, the Ontario Ministries of Environment and Natural Resources and Ontario Hydro, the Biological Research Section undertook to assess the effects of industrialization at Nanticoke on the aquatic resources of Long Point Bay. Based on data collected from 1968 through 1983 by Ontario Hydro and the Ministries of Environment and Natural Resources, it was determined that although several local effects of industrialization exist the impact of these on valued resources of the area was small or negligable.

Sir Adam Beck Flow Restriction

In the fall of 1986, a planned shutdown of Sir Adam Beck 1 and 2 provided an opportunity for a preliminary investigation of biological agents which might account for an observed seasonal flow reduction in the SAB Canal 1 and the two tunnel intakes. At the request of Design and Development Division - Generation, Biological Research carried out visual inspections and biological sampling of the canal wall, and identified biological samples collected by contract divers in the tunnel portal. Considerable weed growth consisting of attached, filamentous algae and aquatic moss occurred throughout SAB Canal 1 to a depth of approximately 5 m, while colonies of bryozoans (simple tube-like invertebrates) encrusted with sand grains were distributed in a patchy fashion

in the deeper areas of the tunnel portal. Further sampling in 1987 is proposed.

Displacement of Larval Fish by a Thermal Discharge

A study of the potential for displacement of larval fish by the thermal discharge of Bruce NGS 'A' has been completed. Small, positively buoyant radio transmitters were released near the discharge plume and their path tracked using radio telemetry. Larval fish were then sampled along the drift path. Drift paths were strongly influenced by changes in longshore lake currents which, in turn, were largely determined by prevailing winds. Under relatively constant winds to the north, north-east, the drift tubes were carried by the longshore current into the Bruce NGS 'A' thermal discharge plume and displaced up to 1 km offshore. Under light and variable wind conditions, the drift tubes were carried by the longshore current into the region of the thermal discharge plume but then moved relatively little and remained stationary at the edge of the plume.

The densities of larval fish within the thermal discharge were significantly lower than densities of larval fish in the zone of mixing of the thermal discharge plume and longshore current or in the nearshore zone before the thermal discharge. The densities of fish in these latter regions were not significantly different.

Movement of Herbicide on a Right-of-Way

Further samples were collected in 1986 from the Des Joachim, right-of-way where an investigation of the movement of herbicide following application has been conducted. Residues of picloram and 2,4-D were detected in soil samples collected up to 36 m from the right-of-way, and in water samples from a lake adjacent to the right-of-way 12 days, 2, 4, 8 and 22 months after herbicide application. By 22 months however, less than 4% of the soil samples collected contained detectable herbicide residues.

Overview

This report has briefly summarized the range of activities undertaken by the Biological Research Section through 1986 and those proposed for 1987. The Section's work as was the case in 1986 will be directed primarily in four program areas: Utilization and Conservation, Nuclear, Transmission and Environment. New initiatives will be made in the areas of biotechnology and remote sensing during 1987.

The Section's programs are supported by external clients, corporate clients and divisional funds. A breakdown of 1986 expenditures and those projected for 1987 by the source of funds and program area is presented in the following table.

Table 1

Source of Funds (% of Total) in 1986
and Projected for 1987

Program Area	External Clients	Corporate Clients	Divisional Funds	Total
General	Ø	2	3	5
(1987)	(Ø)	(Ø)	(Ø)	(Ø)
Utilization and Conservation	Ø	Ø	6	6
(1987)	(Ø)	(Ø)	(7)	(7)
Transmission	Ø	Ø	7	7
(1987)	(Ø)	(Ø)	(11)	(11)
Distribution	Ø	Ø	1	1
(1987)	(Ø)	(Ø)	(Ø)	(Ø)
Nuclear	Ø	Ø	4	4
(1987)	(Ø)	(4)	(11)	(15)
Environment	13	52	9	74
(1987)	(6)	(50)	(10)	66
General Technical Activities	Ø	Ø	3	3
(1987)	(Ø)	(Ø)	(1)	(1)
Total	13	54	33	
(1987)	(6)	(54)	(40)	

Historically the Section has relied on transfer funding in environmental areas, particularly aquatic environmental studies, however, over the past several years the Section has developed and is continuing to develop capabilities in other areas of interest to Ontario Hydro through the use of divisional funds. While our capabilities in environmental areas will be maintained to continue to support our traditional corporate clients, the Section will encourage the use of our developing capability in other areas by interested groups within the corporation.

Approved:

for M.R. Booth
Acting Manager
Chemical Research Department

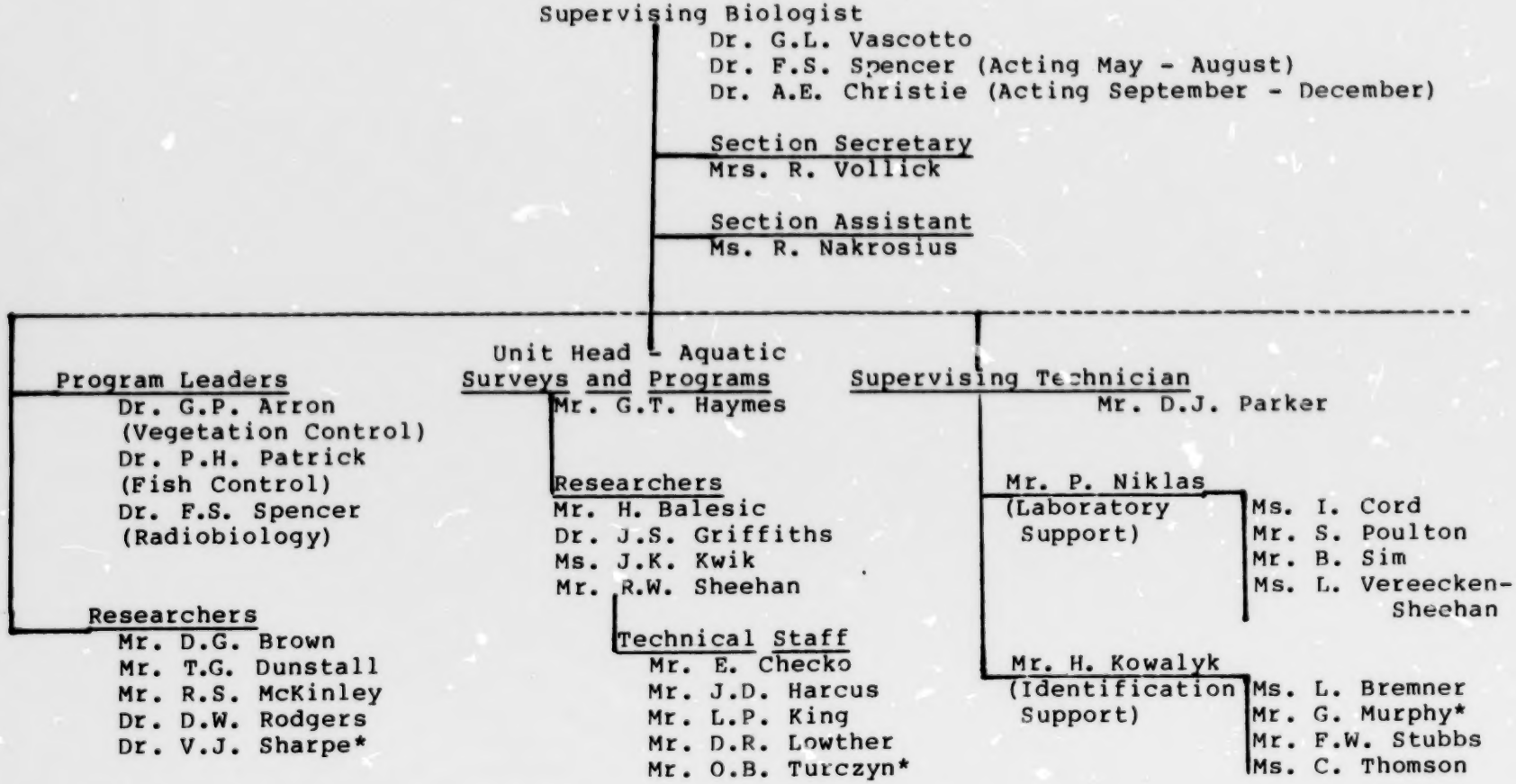
Submitted:

G.T. Haymes
Acting Supervising Biologist
Biological Research Section

GTH:djb

Appendix A

Biological Research Section Organization Chart - 1986



* Left Section During 1986

APPENDIX B

Reports Issued During 1986

Ontario Hydro Research Division Report No CB85-2-K. G.P. Arron. Herbicide Content of Water Samples Collected in 1985 Near the Herbicide Study Area, Wesleyville GS. January 14, 1986.

Ontario Hydro Research Division Report No CB86-1-K. G.P. Arron. Progress Report: Effect of Trunk Injection of the Growth Regulators EL-500 and PP333 on Sprout Growth in Trimmed Silver Maple Trees. February 5, 1986.

Ontario Hydro Research Division Report No C86-7-K. G.P. Arron. Progress Report: McCowan Road Right-of-Way Study; Stump Sprouts After One Growing Season. February 27, 1986.

Ontario Hydro Research Division Report No CB86-2-K. G.P. Arron. Report on Tree Growth Regulator Symposium, February 18-21, 1986. March 18, 1986.

Ontario Hydro Research Division Report No CB86-6-K, G.P. Arron. Report on Annual Meeting of the International Society of Arboriculture (I.S.A.) August 10-13, 1986, San Antonio, Texas. August 29, 1986.

Ontario Hydro Research Division Report No 86-184-K. G.P. Arron. Herbicide Content of Water Samples Collected in 1986 Near the Herbicide Study Area, Wesleyville GS. December 9, 1986.

Ontario Hydro Research Division Report No 86-166-K. H. Balesic. Bruce GS 'B' Commissioning Biological Study Year I - 1983. August 1, 1986.

Ontario Hydro Research Division Report No 85-319-K. T.G. Dunstall. Biosynthesis of Deuterated Organic Compounds for Lubricant Applications. January 31, 1986.

Ontario Hydro Research Division Report No C86-45-K. T.G. Dunstall. Attendance at the International Symposium on Immobilized Enzymes and Cells. July 30, 1986.

Ontario Hydro Research Division Report No 86-38-K. G.T. Haymes. Atikokan GS Preoperational Aquatic Survey - Three-Year Summary, 1981-1983. April 8, 1986.

Ontario Hydro Research Division Report No 86-190-K. R.S. McKinley and B. Sim. Assessment of Ichthyoplankton Entrainment at Bruce NGS 'A' - 1985. November 5, 1986.

Ontario Hydro Research Division Report No CB86-5-K. D.J. Parker. Bacteriological Analyses of Pickering Heat Exchanger Samples. July 30, 1986.

Ontario Hydro Research Division Report No C86-13-K. P.H. Patrick. Attendance at Fish Symposium in Norway. February 19, 1986.

Ontario Hydro Research Division Report CB86-4-K. P.H. Patrick and R.S. McKinley. Initial Responses of Adult Gizzard Shad to Sound and Strobe Light. August 5, 1986.

Ontario Hydro Research Division Report No 86-261-K. D.W. Rodgers. Partitioning of Gamma-Emitting Radionuclides Between Water and Lake Ontario Sediments. November 17, 1986.

Ontario Hydro Research Division Report No CB86-3-K. V.J. Sharpe. Biofouling and Corrosion of Heat Exchangers. May 28, 1986.

Ontario Hydro Research Division Report No 86-44-K. V.J. Sharpe. Toxicity and Biodegradability of Darlington Feeder Header Assembly Cleaning Wastes. June 20, 1986.

Ontario Hydro Research Division Report No 86-158-K. V.J. Sharpe. Evaluation of Microbial Processes in Radioactive Waste Disposal. July 23, 1986.

Ontario Hydro Research Division Report No 86-129-K. G.L. Vascotto. Biological Research Section - 1985 Annual Report. May 15, 1986.

Ontario Hydro Research Division Report No 86-267-K. G.L. Vascotto. The Influence of Cover Strips on the Distribution and Activity Patterns of Macrobrachium rosenbergii. October 2, 1986.

External Reports

Empire State Electric Energy Research Corp Report No 85-14. Fish Protection: Sonic Deterrents. P.H. Patrick and R.S. McKinley.

APPENDIX C

List of Publications Issued During 1986

Arron, G.P. 1986. Effect of trunk injection of flurprimidal and paclobutrizol on sprout growth in silver maple. Journal of Arboriculture 12(9): 233-236.

Haymes, G.T. and P.H. Patrick. 1986. Exclusion of adult alewife, Alosa pseudoharengus, using low frequency sound for application at water intakes. Canadian Journal of Fisheries and Aquatic Sciences 43: 855-862.

Patrick, P.H. 1986. Behavioural systems to guide or divert fish at hydro-electric facilities. Canadian Electrical Assn. Research Bulletin.

Rodgers, D.W. 1986. Tritium dynamics in juvenile rainbow trout, Salmo gairdneri Health Physics 50: 89-98.

APPENDIX D

List of Conference Papers Presented During 1986

Author	Title	Conference	Date	Location
Arron, G.P.	The effect of trunk injection of growth regulators on sprout growth in silver maple	"Gibberellin biosynthesis inhibitors - Symposium	19/2/86	San Francisco CA
Arron, G.P.	Effect of trunk injection of flurprimedol and paclobutrazol on sprout growth in silver maple	International Society of Arboriculture Annual Conference	13/8/86	San Antonio TX
McKinley, R.S.	Assessment of Icthyoplankton Entrainment	IAGLR Conference	25/5/86	Toronto
McKinley, R.S.	Fish Sampling Strategies	N.S. Power Workshop	4/12/86	Annapolis
Patrick, P.H.	Fish Control Strategies	N.S. Power	4/12/86	Annapolis
Patrick, P.H.	Fish Exclusion and Guidance Schemes	Fish Symposium	22/1/86	Lillehammer Norway
Spencer,F.S. T.G. Dunstall	MolecularTritium Conversion in Vegetation, Litter and Soil	Environmental and Human Risks of Tritium-Workshop	17/2/86	Karlsruhe West Germany

APPENDIX E

External Contracts Carried Out in 1986

Principal Investigators	Title	Funded by	Amount
G.T. Haymes and T.G. Dunstall	Influence of Industrialization on the Ecology of Long Point Bay in the vicinity of Nanticoke 1968 - 1983	Stelco Texaco Ministry of Environment Ministry of Natural Resources Ontario Hydro	80 K
P.H. Patrick	Responses of Fish to Sound	Power Authority of New York	132 K
P.H. Patrick and R.S. McKinley	Field Evaluation of Fish Behavioural Devices at Hydro-Electric Facilities	CEA	123 K
P.H. Patrick and R.S. McKinley	Fish Diversion Systems - 1986	EPRI	147 K

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Mr. G.L. Wortman	Design & Development - Trans, H8G5
Mr. G.E. Fraser	Distribution Systems, U6A6
Mr. D.A. Lee	Health & Safety, H2A20
Mr. D.E. Anderson	New Business Ventures, C27A3
Mr. S.T. Griffiths	Transmission Operation, U8A5
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